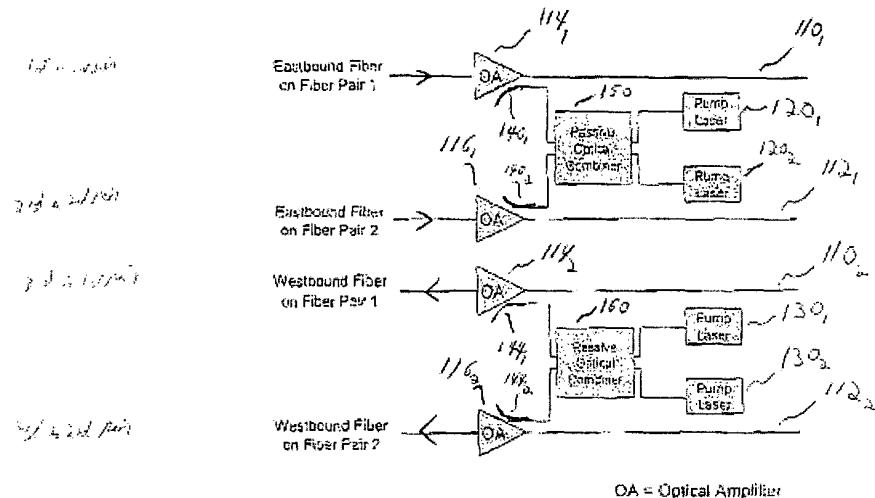


## Invention 1b.

Another method of pump redundancy is to have two optical pumps that are combined through a passive optical combiner and the combined output be split and used to pump two separate optical amplifiers on two separate fiber pairs.

Referring to Figure 2, it can be seen that upon the failure of any single pump laser the remaining pump laser that it is being combined with will increase its output power to make up for the loss of the first pump. If two pump lasers fail that are associated with fibers carrying traffic in the same direction, then the ability to carry traffic on the fibers going in the opposite direction is preserved. In order for all traffic on both fiber pairs to be interrupted it is necessary for all four pump lasers to fail.



Invention 1c.

An extension upon Invention 1b (see Figure 3) includes the concept of recycling excess optical pump power exiting from the end of the eastbound optical amplifiers and using it to pump the westbound optical amplifiers in the counter-propagating direction. The same will hold true for the westbound amplifiers recycled pump power being used to pump eastbound optical amplifiers in the counter-propagating direction. This provides for the additional level of redundancy such that if any three pump lasers fail there will still be sufficient pump power to provide amplifier gain for all four amplifiers.

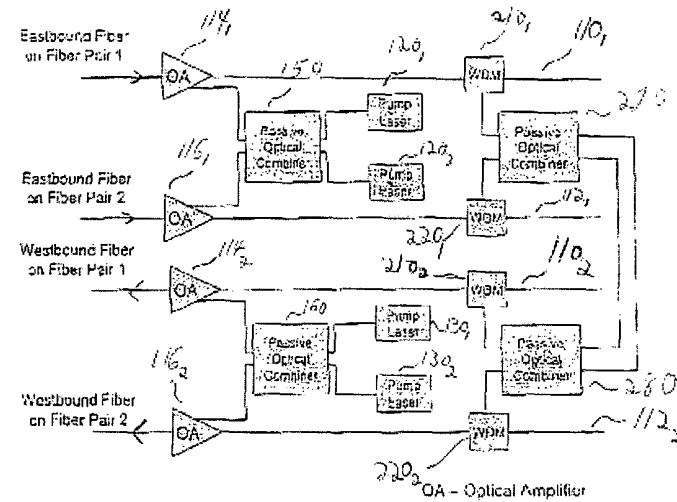


Figure 2